Science

Genre	Comprehension Skill	Text Features	Science Content
Nonfiction	Cause and Effect	• Captions • Charts • Diagrams • Glossary	Climate and Weather

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Science

Physical Science

Earth's Climate and Weather

by Colin Kong

Vocabulary

air mass
air pressure
atmosphere
climate
front
humidity
meteorologists
relative humidity
weather

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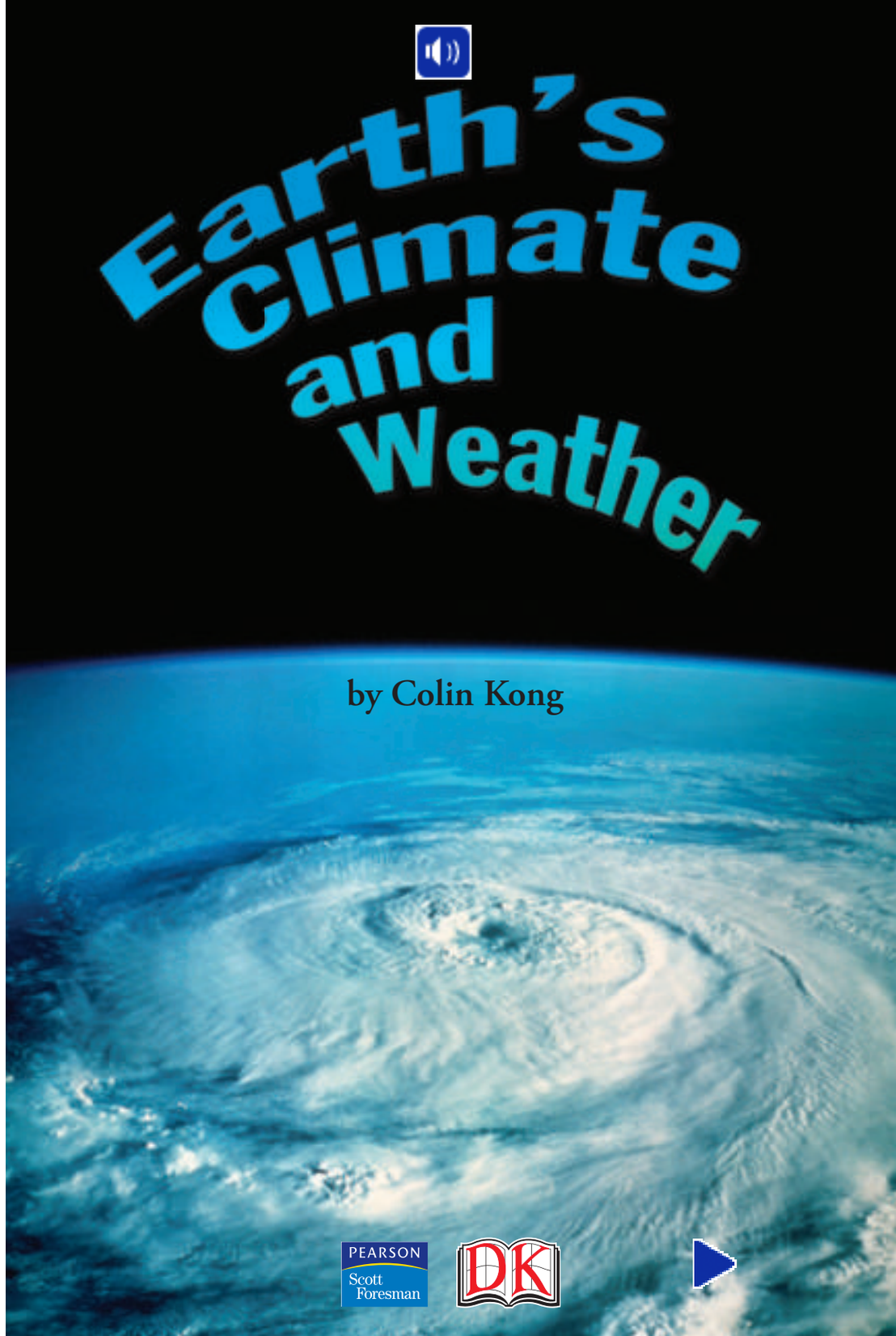

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Earth's Atmosphere

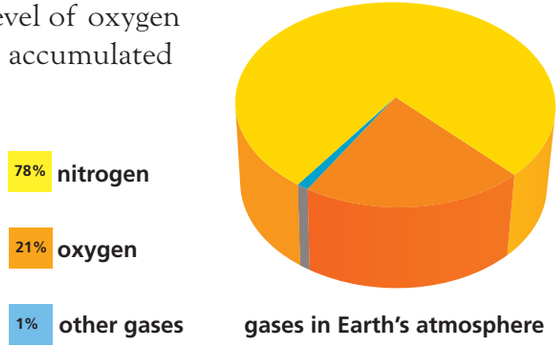
The different layers in Earth's atmosphere are made up of gases. Each layer has different ranges of air pressure and temperature. Winds are created when there are differences in air pressure.

Gases in the Atmosphere

Air surrounds you all the time. You cannot see it or smell it, but it is there. Some planets are surrounded by a blanket of air called an **atmosphere.** Earth's atmosphere is made up of many different gases, but it is mostly nitrogen and oxygen. There are different layers to Earth's atmosphere, each with its own characteristics. Compared to Earth's total size, its atmosphere is very thin.

Many of the gases from Earth's atmosphere came from the molten rock within Earth. When molten rock cools, gases such as nitrogen, water vapor, and carbon dioxide are released. Some of the gases are trapped within Earth, while others escape as volcanoes erupt. This process has been going on for more than four billion years.

Earth's atmosphere did not always have the same level of oxygen that it has today. As more plants and trees grew on Earth, they took in carbon dioxide from the atmosphere. Then through photosynthesis, they released oxygen. The current level of oxygen in our atmosphere has accumulated over millions of years.



gases in Earth's atmosphere

When volcanoes erupt they release gases such as nitrogen, water vapor, and carbon dioxide into Earth's atmosphere.

Air Pressure and Temperature

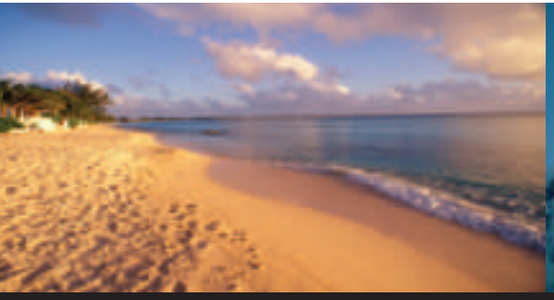
Gases are made of very small particles that are constantly moving. They move around and bump into other matter. **Air pressure** is the measure of force with which air particles push on matter. As you pump air into your bicycle tires, the air particles start to fill in and push on the walls inside the tires. The tires get firmer because of the air pressure inside.

Air does not only push down on you. It pushes on all sides. Luckily, the air inside your body is pushing out with the same force as air outside is pushing in. Because of this you do not feel the pressure of the air. Cool air particles are packed together more closely than warm air particles. The result is greater air pressure in cool air.

Air Pressure and Altitude

Air pressure changes with altitude. It is greatest at Earth's surface because there are more air particles above you that push down. At higher altitudes, air pressure decreases because there are fewer air particles from above pushing down. Air pressure is measured in metric units called millibars (mb).

When flying in an airplane, you feel the effects of the change in air pressure. Your ears pop as you are moving from one altitude to another. You feel the popping because the pressure inside your ears is adapting to the change in outside air pressure. The pressure inside your ears is becoming equal to the pressure outside.

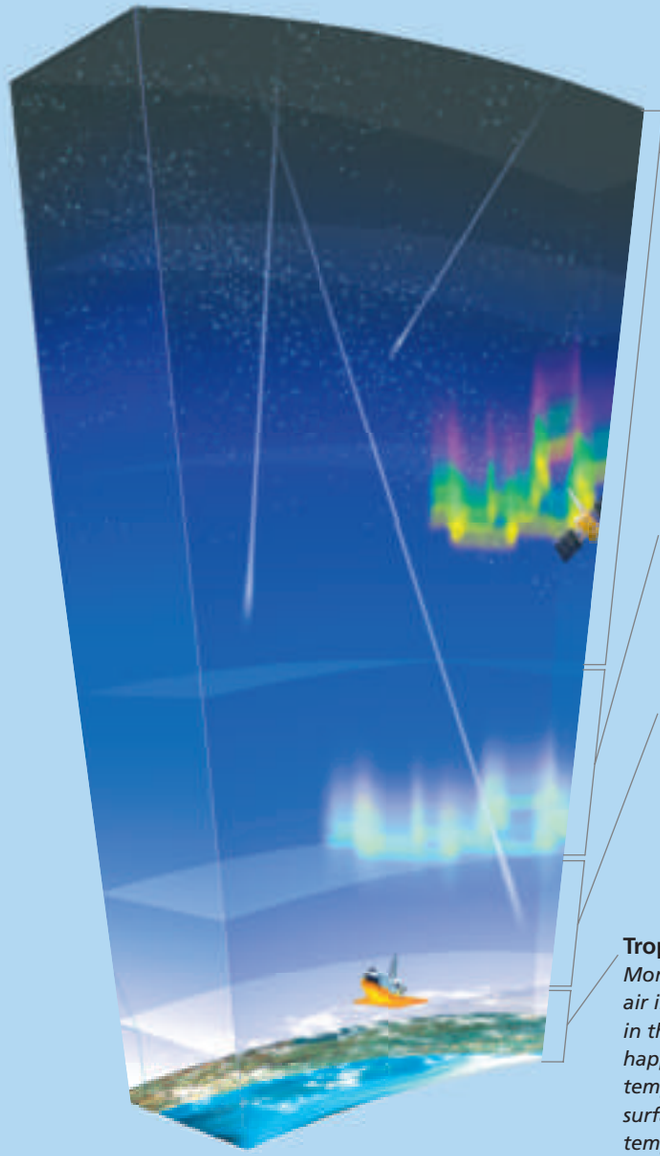


Cayman Island beach: air pressure of 1,000 mb at sea level.

Mt. Everest: air pressure of 330 mb at about 8,900 meters of altitude.

Layers of the Atmosphere

Earth's atmosphere is made up of different layers. It is not the same from top to bottom. Each layer has its own characteristics.



Thermosphere
In this layer, air particles are far apart. As you move higher up in this layer, temperatures get hotter because this layer absorbs dangerous rays from the Sun.

Mesosphere
This is the coldest layer in Earth's atmosphere. As you move higher up in this layer, temperatures get colder.

Stratosphere
Most of Earth's ozone is in this layer. Ozone is a gas that absorbs harmful ultraviolet rays from the Sun. The ozone prevents these rays from reaching Earth's surface.

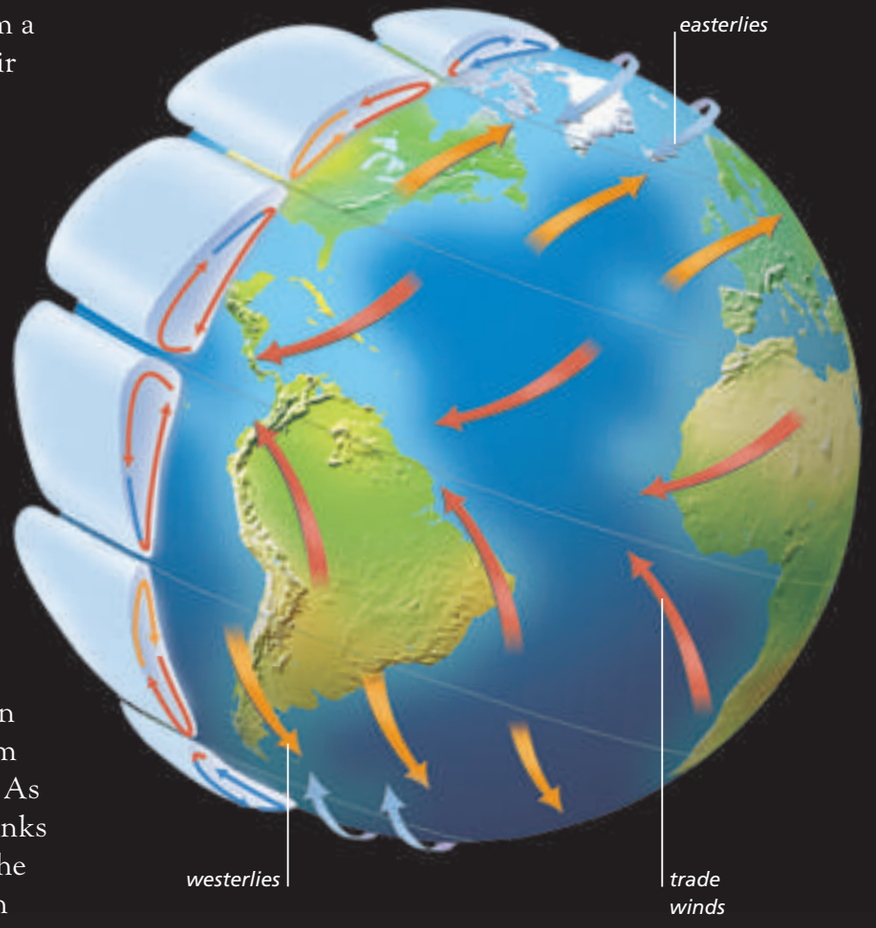
Troposphere
More than 75 percent of all the air in Earth's atmosphere is found in this layer. All weather activities happen here. The warmest temperatures are near Earth's surface, but as altitude increases, temperature and pressure decrease.

Global Winds

Wind is moving air. It is caused by differences in air pressure. Usually winds move from high-pressure areas to low-pressure areas. Releasing air from a balloon is a good example of this. Air rushes out from inside the balloon because air pressure is higher inside than outside the balloon.

Differences in air temperature cause differences in air pressure. When air is heated, its particles move faster and expand. This warm air is less dense than cooler air, so it rises above cooler air. A hot air balloon floats in this way.

The Sun does not warm all places on Earth equally. The air near the equator is much warmer than the air near the poles. As the air near the equator warms, expands, and rises, cooler air blows in to take its place. In this way, the warm air is pushed away from the equator. As it rises higher it begins to cool and sinks back to Earth's surface. This forms the cycles of air movement illustrated on the left side of this globe. Earth's rotation bends these winds as shown by the arrows.



Warm air rises over the equator and cools. At about 30° north of the equator the air cools enough and the pressure rises enough to create winds that blow from east to west back toward the equator. They are called trade winds.

Differences in air pressure and air temperature can also create local winds. You probably experienced these local winds if you have spent time by any large body of water, such as an ocean. When the Sun is shining during the day, heat builds up on land. The temperature of water does not rise as quickly as the temperature on land, so the Sun does not affect the water's temperature as much. As the air above the land becomes warmer, it rises. The cool air that comes in from over the water replaces this air. As a result, winds move from the water to the land. At night, the airflow is reversed.

Winds and Local Weather

Different regions in the world sometimes have very different weather patterns. Local weather is affected by jet streams. They are high-speed bands of winds that blow in the upper troposphere and lower stratosphere. These winds move from west to east. Jet streams affect day-to-day weather and seasons.

Sailboats need local winds in order to maneuver in the water.

Clouds and Precipitation

When surface water—from puddles to oceans—evaporates, it enters the atmosphere. When air that contains water vapor rises and cools, clouds form. Clouds can form precipitation, such as sleet, snow, or hail.

Humidity

Have you ever walked outside and just started sweating because it was so hot and muggy? It was probably a result of humidity. **Humidity** is the amount of water vapor in the air.

Water enters the atmosphere as water vapor. This is part of the water cycle. Air can hold different amounts of water vapor. Warm air can hold more water vapor than cool air. Then, as air gets cooler, the water vapor condenses. It changes from a gas to a liquid, forming dew, fog, or clouds.

Air can hold only a certain amount of water. **Relative humidity** is the amount of water vapor *actually* in the air as compared to the amount of water vapor the air *can* hold at that temperature. If the relative humidity is 50 percent at 34°C, the air has half the amount of water vapor it can hold at that temperature. On very hot and humid days, the relative humidity can reach almost 100 percent.

Clouds

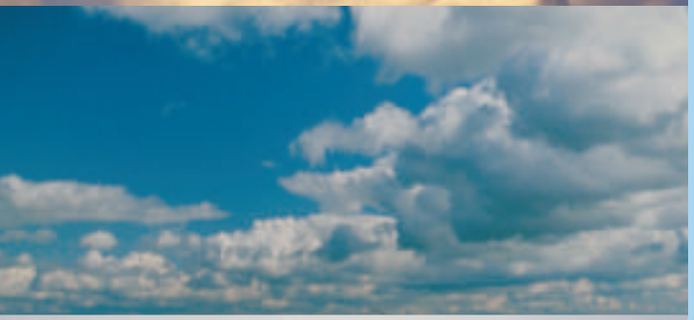
Clouds form when air containing water vapor rises and cools. Since cooler air cannot hold as much water vapor, the water in the rising air condenses. It forms tiny droplets around small particles in the air, such as dust, smoke, and salt. These droplets float in the air. Clouds are made up of millions of these water droplets. If the temperature in the clouds is cold enough, the droplets freeze to form ice crystals. As more water droplets or ice crystals form, the cloud grows larger in size.

Clouds vary in their shape and their height above Earth's surface. Based on these qualities, there are three main classifications of clouds: cirrus, cumulus, and stratus. All other clouds are modifications or a combination of these.

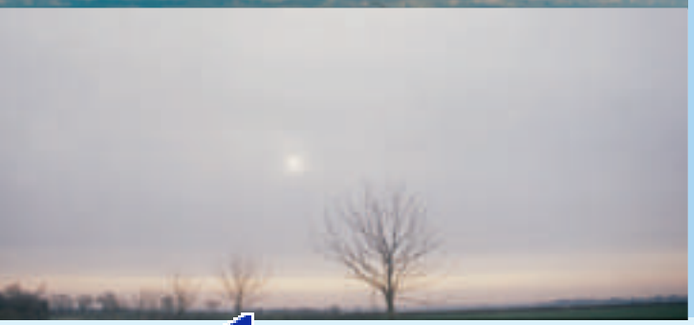
Cirrus clouds look thin and feathery. Because they form high in the atmosphere where temperatures are below 0°C. Cirrus clouds are made of ice crystals.

Cirrocumulus clouds are fluffy clouds that form high in the atmosphere. They are made of ice crystals. They do not usually produce precipitation.

Cumulonimbus clouds are dark and heavy. They can reach high into the atmosphere. They are called thunderheads because they usually result in a short, heavy rainfall or a thunderstorm.



Cumulus clouds are close to Earth's surface. These puffy clouds stack up on top of one another. Cumulus clouds are made up of air warmed by the land that rises into the atmosphere.



Stratus clouds are flat, white clouds. They produce mist or a steady drizzle.

Types of Precipitation

Precipitation is any form of moisture that falls from the atmosphere to Earth's surface. It can be rain, sleet, snow, or hail. Before a cloud can produce precipitation, it must accumulate a lot of moisture. The form that falls depends on the temperature and other weather conditions.

Rain and Snow

Both water droplets and ice crystals can form rain. If water droplets fall through temperatures above freezing, rain falls from the clouds. If ice crystals fall through temperatures above freezing, it melts to form rain.

If the temperature below the cloud is below freezing, the ice crystals join together to form snowflakes. These crystals can either be feathery and six-sided or flat hexagons. The temperature and amount of moisture in a cloud determine the shape of the snowflakes. The temperature of the ground is also important. Dry snow, which is light and powdery, forms if the ground is cold. Wet snow, which is denser, accumulates if ground temperatures are warm.

Wet snow accumulates on these cows because it is heavier, causing it to stick together.

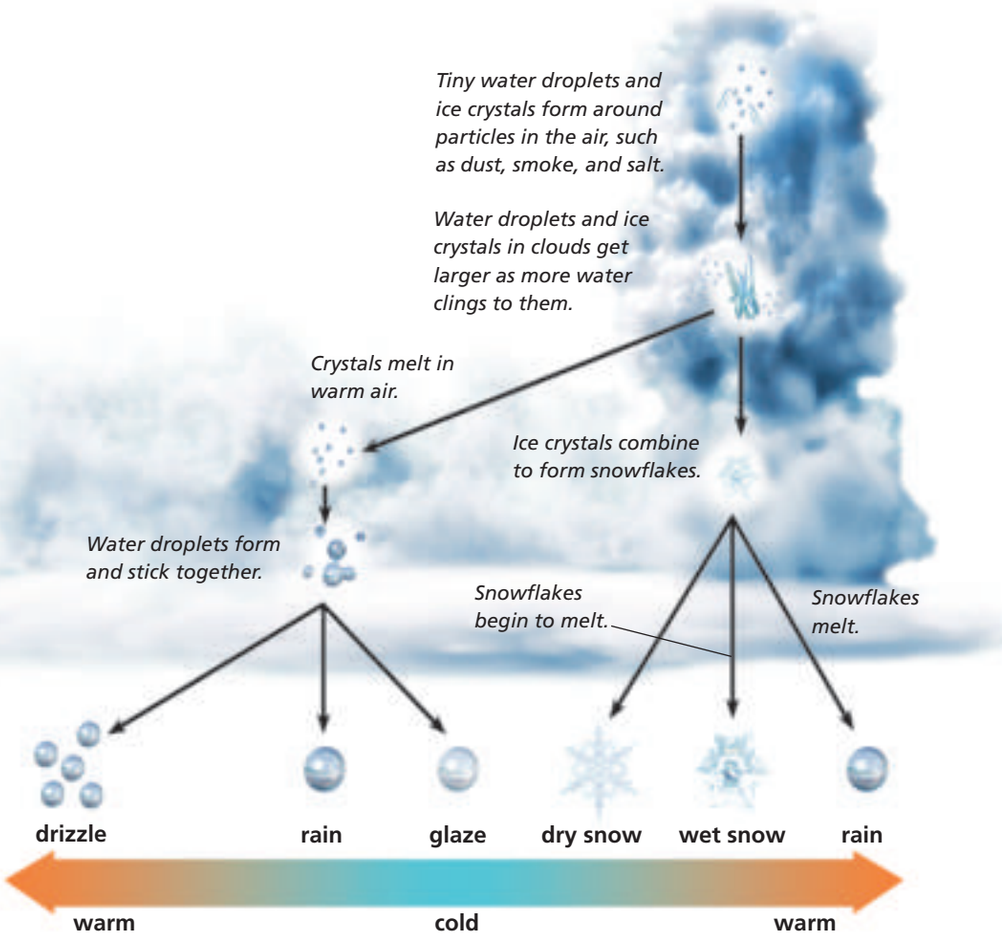
Sleet and Hail

Sleet forms when water droplets fall through a layer of freezing air. The droplets freeze and reach the ground as small particles of ice. Freezing rain, or glaze, occurs when water droplets pass through cold air that is not cold enough to freeze the drops. The raindrops freeze only after hitting a frozen surface.

Hail falls in the form of hard, round particles of ice. This precipitation usually occurs in warm summer months. Hail forms when winds toss ice crystals up and down. As they move around, droplets of water attach to the ice crystals and freeze. Soon the hailstones grow to be too heavy to stay in the clouds. They fall to the ground. A hailstone can be as large as a baseball when it falls from the sky!

How Precipitation Forms

Water droplets and ice crystals in clouds may start out as being very small. But they get larger as more water clings to them. Precipitation forms when these droplets and ice crystals become too heavy to remain in the atmosphere. The form of precipitation that falls depends on the temperature and weather conditions the precipitation falls through.


Tiny water droplets and ice crystals form around particles in the air, such as dust, smoke, and salt.
Water droplets and ice crystals in clouds get larger as more water clings to them.
Crystals melt in warm air.
Ice crystals combine to form snowflakes.
Water droplets form and stick together.
Snowflakes begin to melt.
Snowflakes melt.
drizzle
rain
glaze
dry snow
wet snow
rain
warm
cold
warm

Weather and Climate

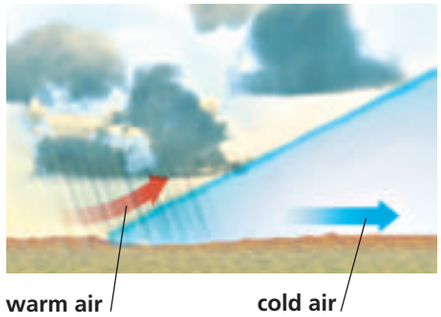
Air Masses and Fronts

Weather is the condition of the atmosphere at a specific time and place. It is always changing due to the different air masses and fronts. You may have seen a weather forecaster on the news speaking about these air masses and fronts.

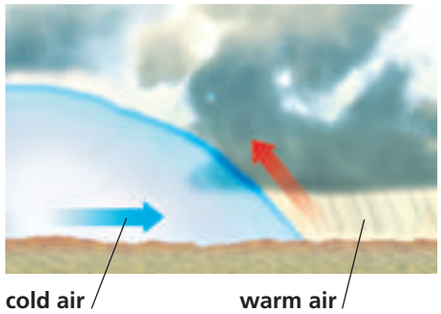
An **air mass** is a very large body of air. The temperature and humidity is similar throughout. An air mass forms when the same air stays over an area for a period of time. This may be for days, a week, or even longer. The temperature and moisture of the air mass come from the area of Earth's surface over which it forms. For example, an air mass forming over the desert would be dry.

When air masses of different temperatures come together, they usually do not mix. A boundary called a **front** forms between these two air masses. The weather at these fronts is often cloudy or stormy. Scientists called **meteorologists** study the weather. They track the movement of air masses very carefully in order to predict weather conditions.

Fronts Moving Across Land



Warm Front
A mass of warm air runs into a mass of cooler air. The warm air moves above the cooler air. The warm air cools and condenses to form clouds. A warm front produces periods of steady rain or drizzle.



Cold Front
A mass of cold air runs into a mass of warm air. The warm air moves above the cold air. As the warm air rises, it cools and condenses to form clouds. Heavy rains or snow may come. Cold fronts move quicker than warm fronts.

Stationary Front
A warm air mass and a cold air mass meet. But they do not move toward one another. A stationary front does not move quickly. It can stay over an area for days. The weather produced is similar to that produced by a warm front.

Severe Weather

At some point you will probably experience some severe weather. Knowing what to do when such weather hits is very important.

Thunderstorms

A thunderstorm is a small, intense storm. It produces strong winds, heavy rain, lightning, and thunder. These storms can occur at any time. But they happen more often in the spring and summer months.

Thunderstorms are dangerous because they bring lightning and heavy rains. Every year, lightning kills more people than tornadoes do. The heavy rains can cause flash flooding.

Tornadoes

A tornado is a rapidly spinning column of air with extremely strong winds. These winds have reached speeds of 419 kilometers per hour. It is difficult to predict tornadoes because they form very quickly from thunderstorms. Tornadoes are dangerous because they can destroy everything in their path.

Tornadoes can happen in any part of the United States, but they are most common in the Midwest. Most tornadoes develop in spring and summer.

Hurricanes

A hurricane is a large, spiraling storm that is fueled by warm water. A hurricane's wind speeds reach at least 120 kilometers per hour. Their strong winds and heavy rains can cause a lot of damage.

A hurricane is made up of many groups of thunderstorms. Hurricanes release a lot of energy. They usually form over warm ocean waters. The warm, moist air keeps a hurricane moving.

Severe Weather Safety Tips

Thunderstorm

- Find shelter in a building or car. Keep windows closed.
- If in the woods, take shelter under the shorter trees. If swimming or boating, find shelter on land.
- If in an open area, squat low to the ground. Put your hands on your knees and lower your head.

Tornado

- Take shelter in a basement or storm shelter.
- If there is no basement or shelter, take cover inside a small room, bathroom, hallway, or closet on the first floor. Stay away from windows.
- If outside, lie face down. Cover your head with your hands.

Hurricane

- Prepare a disaster plan and a disaster supply kit ahead of time.
- Evacuate if told to do so. If you do not need to evacuate, stay indoors away from windows. Take cover in a bathtub or hallway.
- Avoid using the phone.

Forecasting Weather

Weather can change very quickly. One minute it can be sunny, and the next minute clouds can roll in for a storm. A weather forecast can help you prepare for the day's conditions. You can find these forecasts on television, in newspapers, on the radio, and on the Internet. If severe weather develops, these sources will provide warnings and safety instructions.

Weather forecasting involves looking at weather conditions all over the world. Meteorologists have to gather data on temperature, wind speed, humidity, and air pressure. Then they put all the data into computers to analyze the information and make predictions. The National Weather Service operates these computers in the United States. Forecasters use the information they gather to predict both local and national weather.

Gathering Data

Weather forecasting is a very complicated process, but meteorologists have many tools they use to gather weather information. They take measurements all over the world many times each day. They have thermometers to measure temperature, barometers to measure air pressure, hygrometers to measure humidity in the air, and anemometers to measure wind speed. Rain gauges measure the amount of precipitation that falls to the ground.

Meteorologists also need to gather data from Earth's atmosphere. For this reason, scientists release weather balloons at hundreds of stations around the world. These balloons are released several times a day to collect data about Earth's weather from the troposphere.

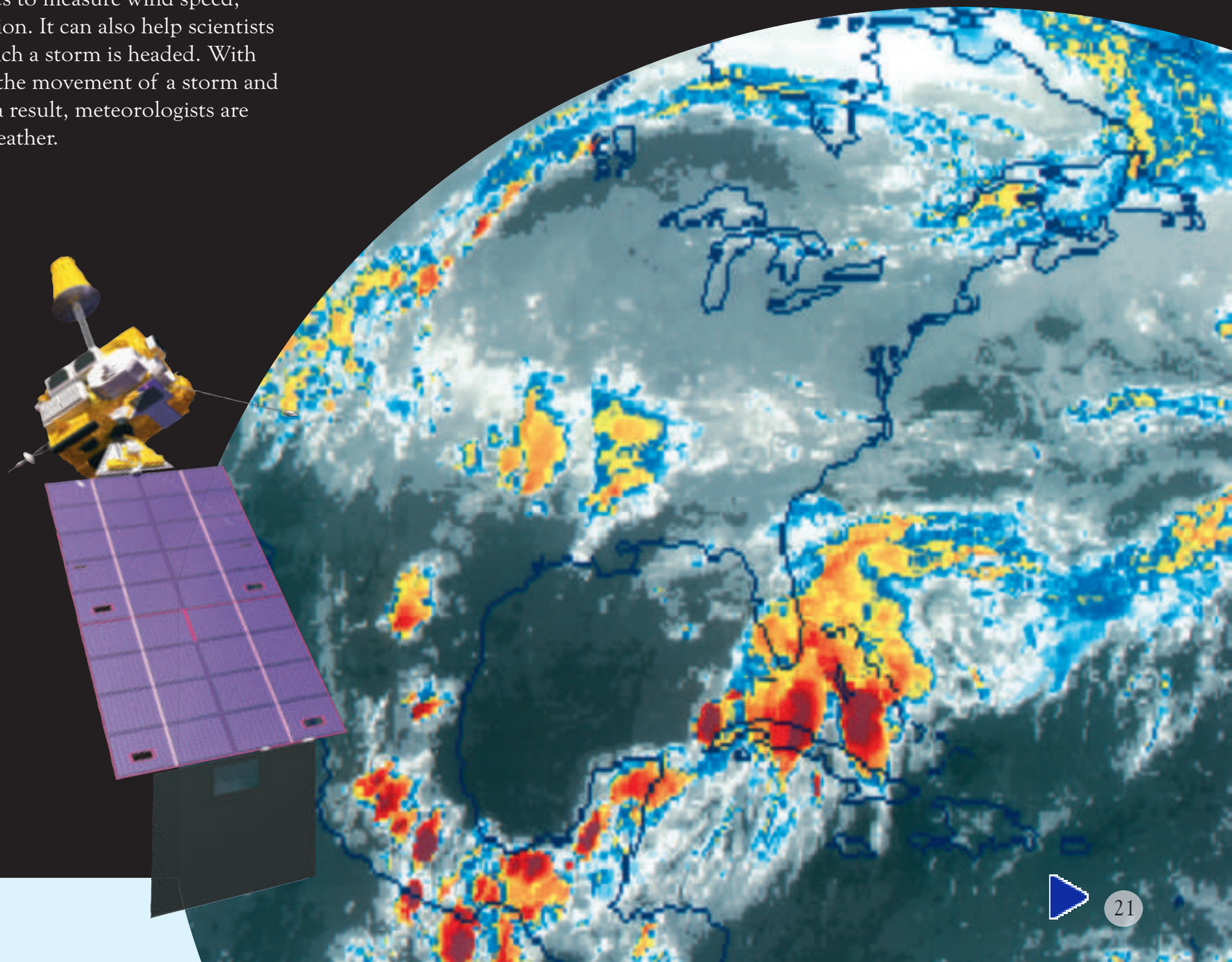
Weather balloons are released all around the world to collect data for meteorologists.

Barometers measure air pressure.

Weather Satellites

With advances in technology, such as Doppler radar and satellites, weather forecasts have improved in accuracy. Doppler radar uses radio waves to measure wind speed, wind direction, and precipitation. It can also help scientists determine the direction in which a storm is headed. With this tool, scientists can watch the movement of a storm and study the winds within it. As a result, meteorologists are better able to predict severe weather.

Far above Earth's surface, satellites are recording images of the planet. From these images, scientists can track weather fronts, hurricanes, and other conditions to help make forecasts. Satellites also track other data, such as solar particles moving toward Earth.



GOES-10 Satellite
Many satellites orbit Earth. The GOES-10 satellite orbits Earth about 35,720 kilometers above the equator and sends back information that helps meteorologists make weather forecasts.

Climate

Weather in an area is constantly changing. However, **climate** is a pattern of weather that occurs in an area over a long period of time. This weather pattern is analyzed over at least thirty years. Climate is usually described in terms of average temperatures and precipitation throughout different seasons.

The climate is different from one area of Earth to another. Many factors affect climate. They include ocean currents, the amount of sunlight an area receives, and the amount of water vapor and carbon dioxide in the air. Study the pictures on these pages to see the many different factors that affect the climate of an area.

Forest fires release carbon dioxide into the atmosphere. As fewer trees remain, carbon dioxide traps heat, which makes areas warmer.

Because our planet is a sphere, different areas of the world receive different amounts of sunlight. Earth's polar regions do not receive much sunlight.

As air rises over mountains, it cools and water vapor condenses. This causes rain to fall on one side of the mountain, while the other side stays dry.

Low clouds reflect sunlight. So clouds such as stratocumulus clouds cause areas to be cooler.

Volcanic eruptions release large amounts of ash and smoke into the atmosphere. This can block sunlight.

Pollution can affect climate. When fossil fuels burn, the amount of carbon dioxide increases in the atmosphere.

Glossary

air mass	a very large body of air with similar properties distributed through it
air pressure	the measure of force with which air particles push on matter
atmosphere	the blanket of air that surrounds a planet
climate	the average condition of the weather at a place over a long period of time
front	a boundary that forms between air masses
humidity	the amount of water vapor in the air
meteorologists	scientists who study the weather
relative humidity	the ratio of the amount of water vapor actually present in the air as compared to the greatest amount possible at the same temperature
weather	the day-to-day condition of the atmosphere at a particular time and place

What did you learn?

1. How does air pressure affect you if you were driving up and then down a mountain road?

2. What is the difference between sleet and freezing rain or glaze?

3. What are three tools that meteorologists use to help gather weather information?

4. **Writing** in Science Climate differs from one area to another, and there are many factors that affect climate. Write to explain how some factors cause the climate to be cool and how other factors cause the climate to be warm. Include details from the book to support your answer.

5. **Cause and Effect** What causes precipitation to form and fall to the ground?